Rift interaction at the Galapágos Triple Junction

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Abstract

The Galapágos Triple Junction is a complex ridge-ridge-ridge triple junction located 1000 km west of the Galapágos Islands in the eastern equatorial Pacific Ocean. A northern ridge-ridge-ridge triple junction intersects the East Pacific Rise at 2°40' N while a southern triple ridge-ridge-ridge junction intersects the East Pacific Rise at 1°10' N. A series of smaller extinct rifts found parallel and to the northeast of the 2°40' N triple junction suggests that rifts associated with this triple junction, similar to the current Incipient Rift, were at one time an active triple junction at 2°40' N along the East Pacific Rise but eventually cease to be active and are carried away from the triple junction with the Cocos plate. Numerical models, in which the geometry and locations of various rifts are varied in the general triple junction vicinity, are analyzed to constrain the factors that have led to the consistent location of secondary rift at the northern triple junction. The results indicate that once a rift has become detached from the East Pacific Rise, a zone of reduced tension forms at the rift tip prohibiting reconnection. Instead, two peaks of tensile stress enhancement form along the East Pacific Rise and are offset from the detached rift indicating where a new crack is likely to form. I show that the magnitude of tensile stress enhancement is controlled by the gap between the detached rift and the East Pacific Rise, but the presence of the Cocos-Nazca Rift controls the location of new rift formation along the ridge of the East Pacific Rise. Therefore, I infer that the sequence of ancient rifts at the 2°40' N triple junction represents the natural consequence of rift disconnection events and their position reflects the history of the gap between the EPR and the Cocos-Nazca Rift.

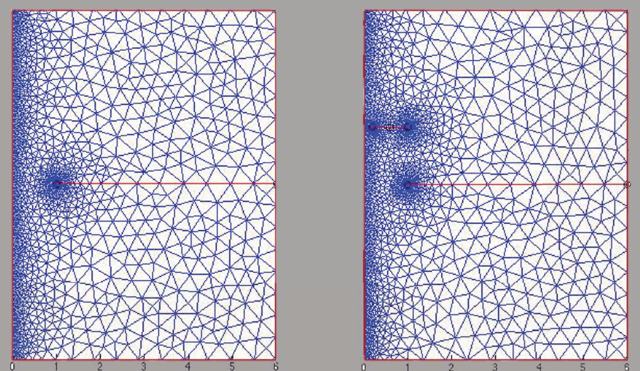
Goals of the study

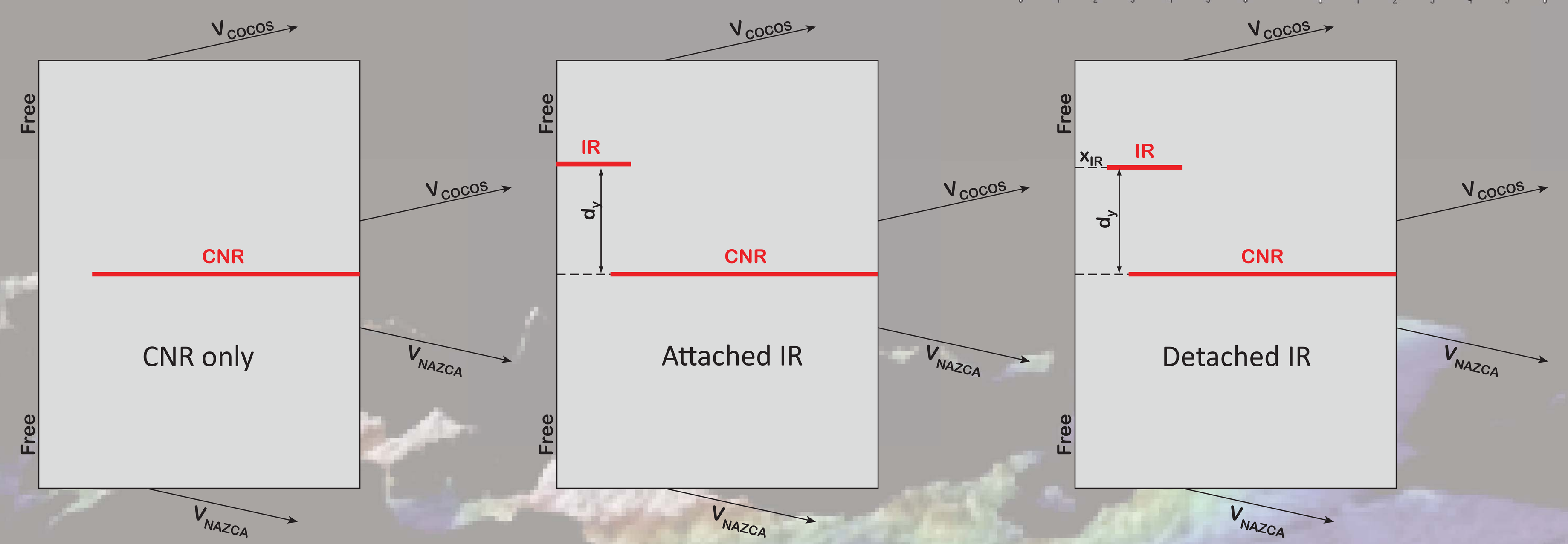
Previous research (Schouten et al., 2008) suggests that the location of the 2°40' N triple junction is due to regional stress field created by the current location of the Cocos-Nazca Rift (CNR) rift tip. **What physical parameters control the location of the rifts at the 2°40' N triple junction?**

Hypothesis: The location of the rifts is controlled by the size of the gap between the CNR and East Pacific Rise (EPR).

Rift Interaction Models

COMSOL® Multiphysics - finite element modeling software
- 2D elastic plate with plane stress approximation
- Map view with non-dimensional variables (D = 50 km)
- Irregular mesh of triangular elements refined along the EPR and rift tips
- Identify regions of stress enhancement along the EPR for varying rift configurations.



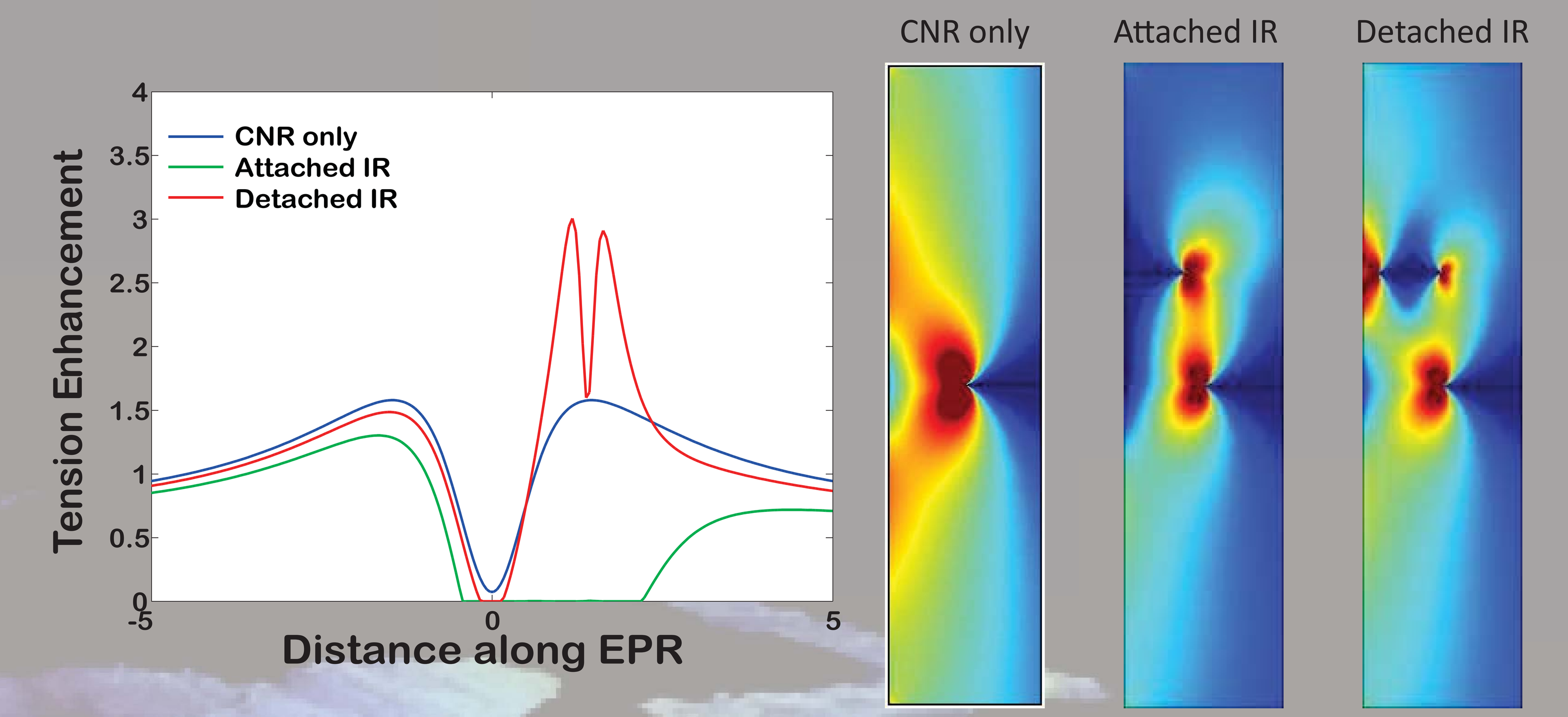


Results

Maps and profiles display the maximum tensile stress enhancement which indicate the regions where new cracking is most likely along the EPR.

If a secondary rift is connected to the EPR (Attached IR series):
- Low tensile stress along the ridge: no rift sequence develops

If a secondary rift is disconnected from the EPR (Detached IR series):
- Reduced tension ahead of detached rift prevents reconnection
- Stress enhancement along EPR forms new rift, offset from the first
- The sense of offset is controlled by the position relative to the CNR

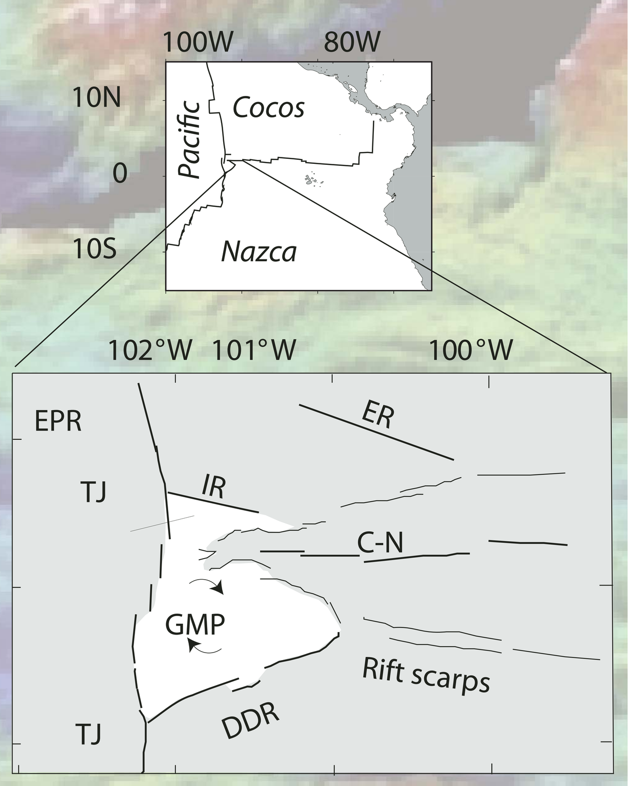


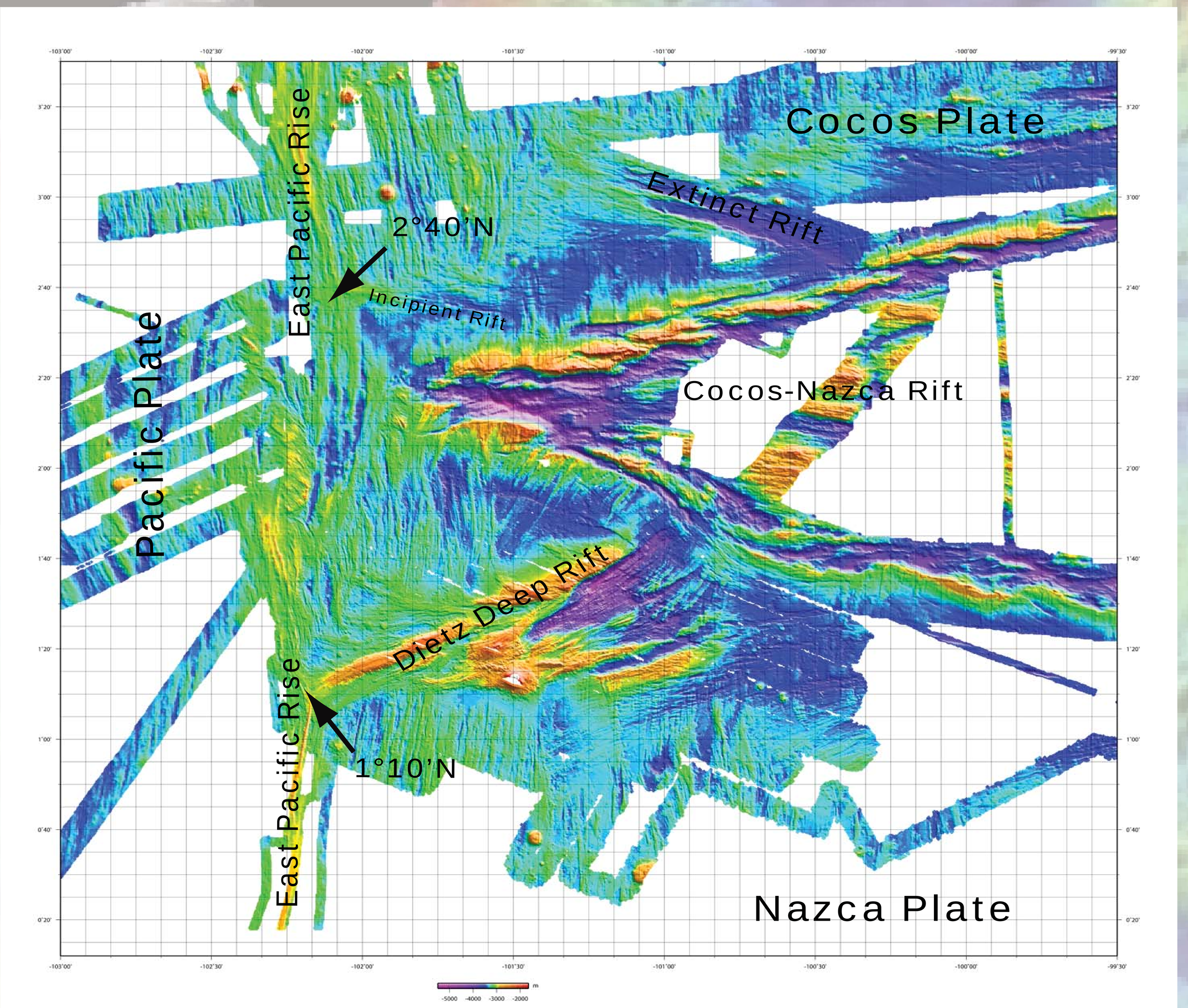
Tectonics of the Galapágos Triple Junction

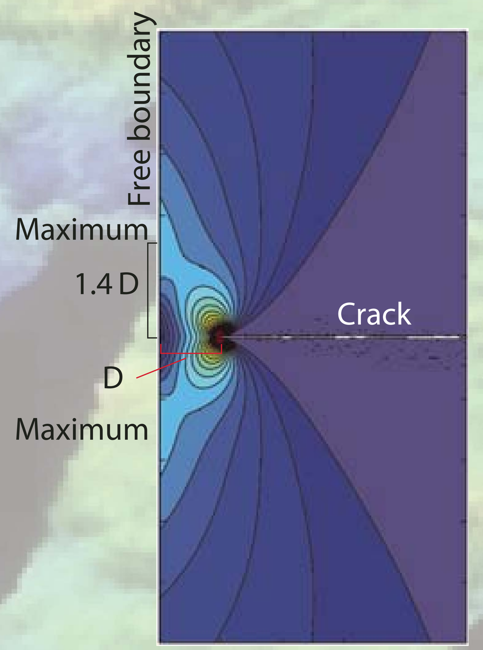
Succession of rifts at the 2°40' N triple junction

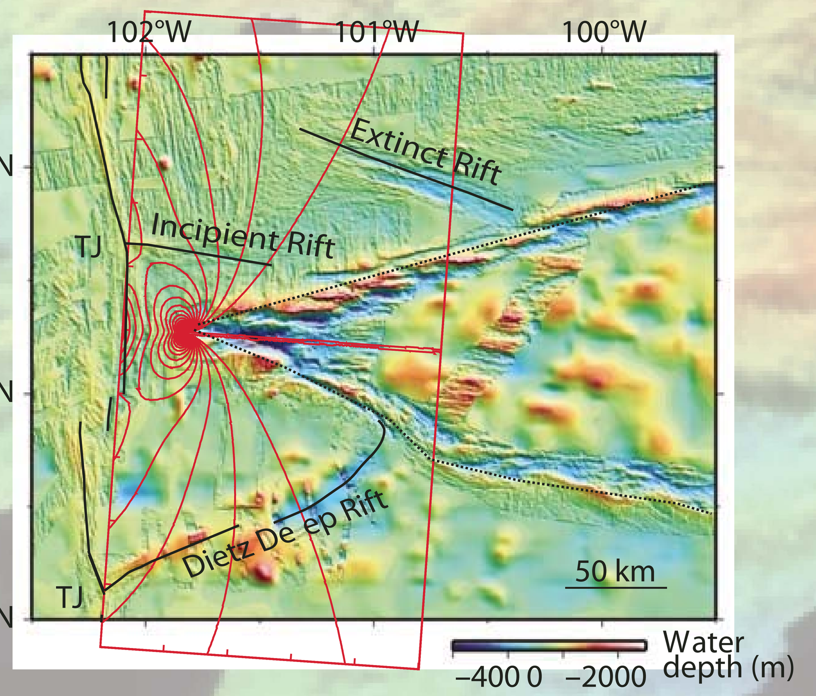
Global scale:
- A ridge-ridge-ridge (RRR) triple junction separating the Pacific, Cocos, and Nazca plates
- East Pacific Rise (EPR): 133 mm/yr & Cocos-Nazca Rift (CNR): 42 mm/yr

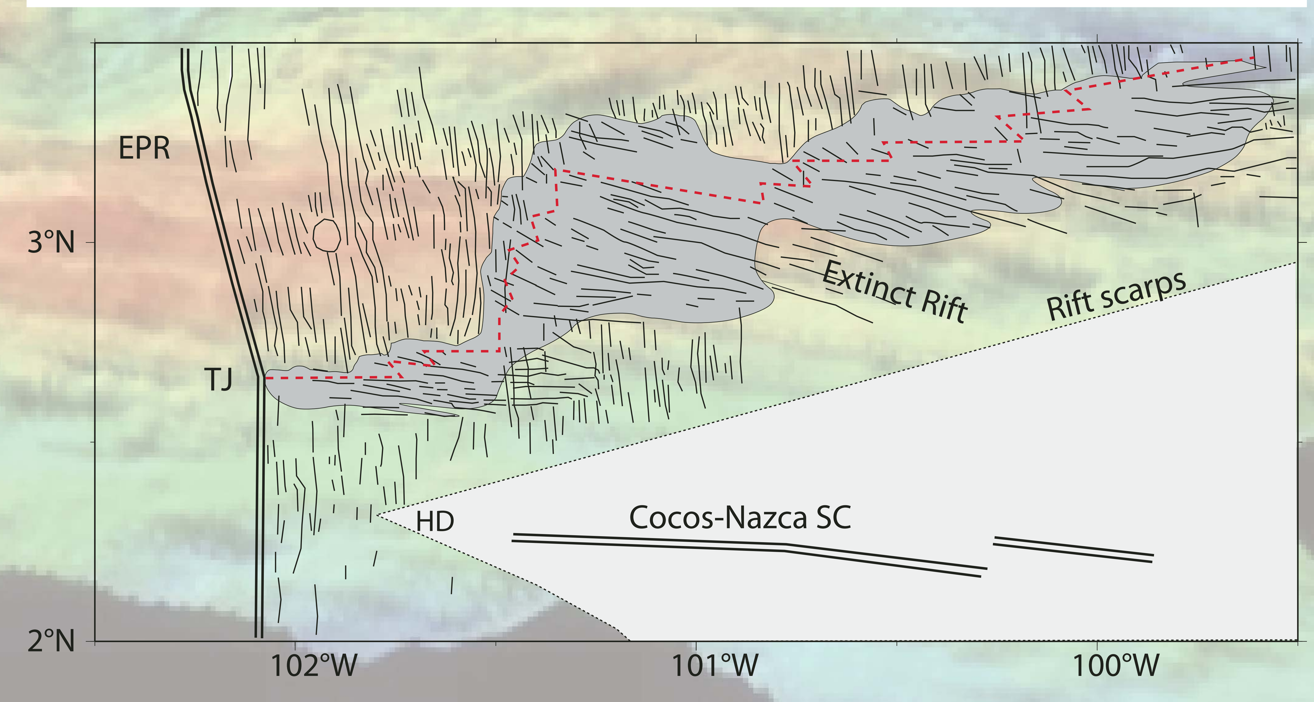
Regional scale:
- Two counter-rotating microplates
- CNR does not connect to the EPR
- 1°10' N triple junction where the Dietz Deep Rift (DDR) connects with the EPR
- 2°40' N triple junction where the Incipient Rift (IR) connects with the EPR
- Change in seafloor morphology delineates a region of ancient rift scars interpreted as detached rifts that were at one time active triple junctions





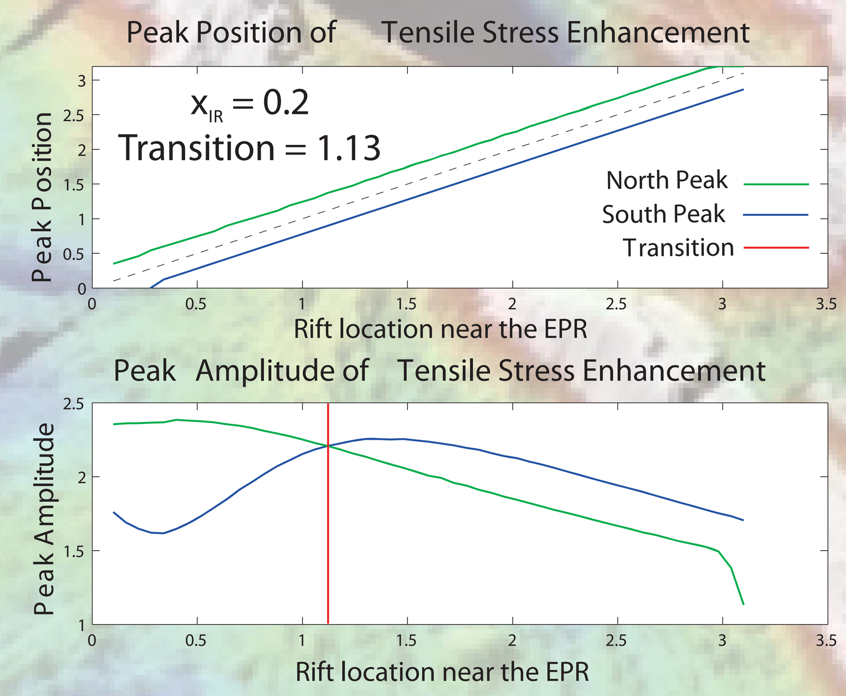




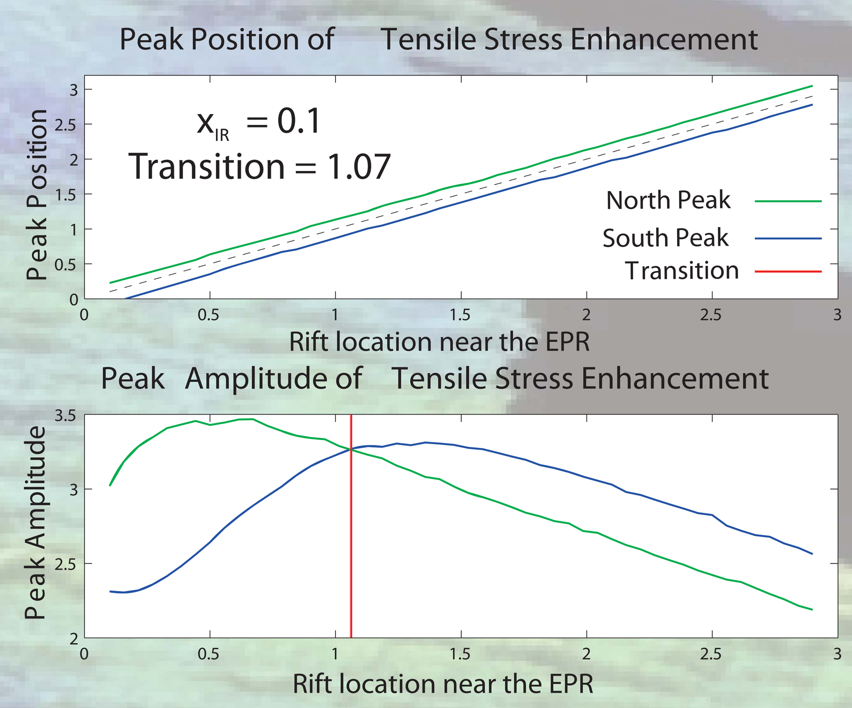


Discussion

Sequence of rifting at 2°40' N



Transition between right-stepping rifts and left-stepping rifts:
- Rifts detaching south of stability window are right-stepping; northward migration along EPR
- Rifts detaching north of stability window are left stepping; southward migration along EPR
- Rifts detaching within stability window alternate right- and left-stepping: little or no long-term migration



Summary

The Galápagos Triple Junction is a complex ridge-ridge-ridge triple junction with two asymmetric triple junctions.
The 2°40' N triple junction is characterized by a series of short-lived rifts:
- The succession of rifts corresponds to a sequence of rift detachment episode and stress enhancement at the EPR that triggers a new rift.
- The direction of stepping between detached and new rift is controlled by the regional stress field
- The position of the rift sequence is controlled by the gap between the CNR and the EPR
- The magnitude of tensile stress enhancement is controlled by the gap between the detached rift and the EPR
- Ridge-ridge-ridge triple junctions are kinematically stable, but mechanically unstable.

Reference

Schouten, H., Smith, D.K., Montési, G.J., Zhu, W., and Klein, E.M., 2008, Cracking of the lithosphere north of the Galápagos triple junction: Geology, v. 36, no. 5, p. 339-342.